

AD816768

MANRL-1121

THE EFFECT OF EARPLUGS ON PASSENGER SPEECH  
RECEPTION IN ROTARY-WING AIRCRAFT

Carl E. Williams, John R. Forstall, and Ward C. Parsons



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**THE EFFECT OF EARPLUGS ON PASSENGER SPEECH  
RECEPTION IN ROTARY-WING AIRCRAFT**

**Carl E. Williams, John R. Forstall, and Ward C. Parsons**

**Bureau of Medicine and Surgery  
MF 12.524.005-7011BX5X**

**Naval Air Systems Command  
A3405314/561B/1F12524402**

**Approved by**

**Ashton Graybiel, M. D.  
Assistant for Scientific Programs**

**Released by**

**Captain N. W. Allebach, MC, USN  
Officer in Charge**

**27 October 1970**

**NAVAL AEROSPACE MEDICAL RESEARCH LABORATORY  
NAVAL AEROSPACE MEDICAL INSTITUTE  
NAVAL AEROSPACE MEDICAL CENTER  
PENSACOLA, FLORIDA 32512**

## SUMMARY PAGE

### THE PROBLEM

Direct person-to-person speech communication is sometimes required in rotary-wing aircraft where high levels of noise make the use of hearing protective devices desirable. The question arises as to what effect earplugs would have on the intelligibility of speech in rotary-wing aircraft.

### FINDINGS

Intelligibility test data obtained in flight as well as in a simulated flight situation indicate that the use of earplugs in rotary-wing aircraft will improve the reception of direct person-to-person speech communication. Moreover, their use will afford protection against the deafening, fatigue, and annoyance effects of the hazardous noise present in rotary-wing aircraft.

### ACKNOWLEDGMENT

The authors wish to express their appreciation to Major Robert D. Schreiber, USMC, Helicopter Training Squadron Eight, Naval Air Station, Ellyson Field, Pensacola for arranging and coordinating the various flights conducted during this study.

## INTRODUCTION

Laboratory studies by Kryter (1) in 1946 showed that the use of earplugs in noise environments that raise the hearing threshold for speech by more than 80 dB does not impair the reception of speech; also, that in some cases where considerable reverberation is present, the use of earplugs will improve speech reception. Kryter's findings, together with some later supporting data from laboratory studies by Pollack (2) and Michael (3), would appear to have application for passengers traveling in rotary-wing aircraft where intense levels of noise often prevent direct person-to-person speech communication and cause the passengers to experience fatigue, annoyance, and a temporary threshold shift in their hearing. Field reports have indicated situations wherein troops emplaning from rotary-wing aircraft sometimes experience hearing threshold shifts of such severity that they are unable to make use of aural cues in detecting enemy movements. In some instances, individuals have been reported to resort to plugging the ears with 45-caliber bullets, cigarettes, or fingers to attenuate the noise.

To determine the effect of earplugs on speech communication in rotary-wing aircraft, a number of intelligibility tests were administered to crews of listeners in a rotary-wing aircraft noise environment, both in the laboratory and in flight.

## METHOD

### SUBJECTS

Five Marine Corps flight candidates, two Navy corpsmen, and two of the experimenters served as talkers and listeners for the intelligibility tests. All subjects demonstrated threshold hearing levels of 15 dB or better (re ISO 1964) at 500, 1000, 2000, and 3000 Hz, and 25 dB or better at 4000 and 6000 Hz for both ears. The Naval Aviators' Speech Discrimination Test (4) was administered to the subjects to determine their ability to understand loud speech in high levels of background noise. All of the subjects performed within normal limits for the test. All subjects were native speakers of General American English.

Each subject was assigned to one of three talker/listener groups; he served as both a talker and a listener for the other two subjects in his group. One of the nine subjects served as a talker and a listener for all three talker/listener groups.

## LABORATORY TESTS

For the laboratory tests the subjects were seated in an IAC Special Type 400 Acoustic Room, modified to provide a diffuse sound field for the realistic simulation of various noise environments. Irregular wall and ceiling surfaces constructed of 5/8" plywood, veneered with a hard plastic sheeting, and a large full-frequency range speaker system installed in one end of the room provided an intense sound field, virtually nondirectional from 30 Hz to 10 kHz. A schematic diagram of the laboratory test environment and talker/listener positions is shown in Figure 1. The distance between the talker and the two listeners was approximately 33 inches. Each talker wore earplugs while reading two word lists of the Modified Rhyme Test (5). A brief description of the test is given in Appendix A. The talkers were instructed to "read the test words in a very loud voice, but not to shout." During the first test the listeners wore V-51R earplugs (closed ear condition); during the second test, the listeners were without ear protection (open ear condition). After a talker read two lists of words, the subjects rotated positions, with the talker becoming one of the listeners and one of the listeners becoming the new talker. To avoid the contribution of visual cues to listener performance, the subjects were instructed to keep their eyes on their response sheets.

## IN-FLIGHT TESTS

For the in-flight tests, the subjects were seated in the passenger area of a TH-1L rotary-wing aircraft. The seating arrangements and test procedures were identical to those employed in the laboratory test situation. The tests were administered during straight and level flight with the doors of the aircraft closed.

## NOISE

The noise during both the laboratory and in-flight test situations was that of a TH-1L rotary-wing aircraft. The noise recording used for the laboratory tests was obtained during straight and level flight operations, with the doors of the aircraft closed. The recording was made by a Kudelski Model Nagra III portable tape recorder and a Brüel and Kjaer Type 2203 sound level meter. A tape loop was made from the in-flight recording to provide a 45-minute tape for playback in the laboratory tests. The recording was played back on an Ampex Model 400 tape recorder whose output was connected to a Pultec Program Equalizer. The latter's output was connected to a 250-watt audio amplifier which powered an array of Altec high-, medium-, and low-frequency loudspeakers. The program equalizer and the amplifier were adjusted until the octave-band levels of the noise within the range 125 through 4000 Hz

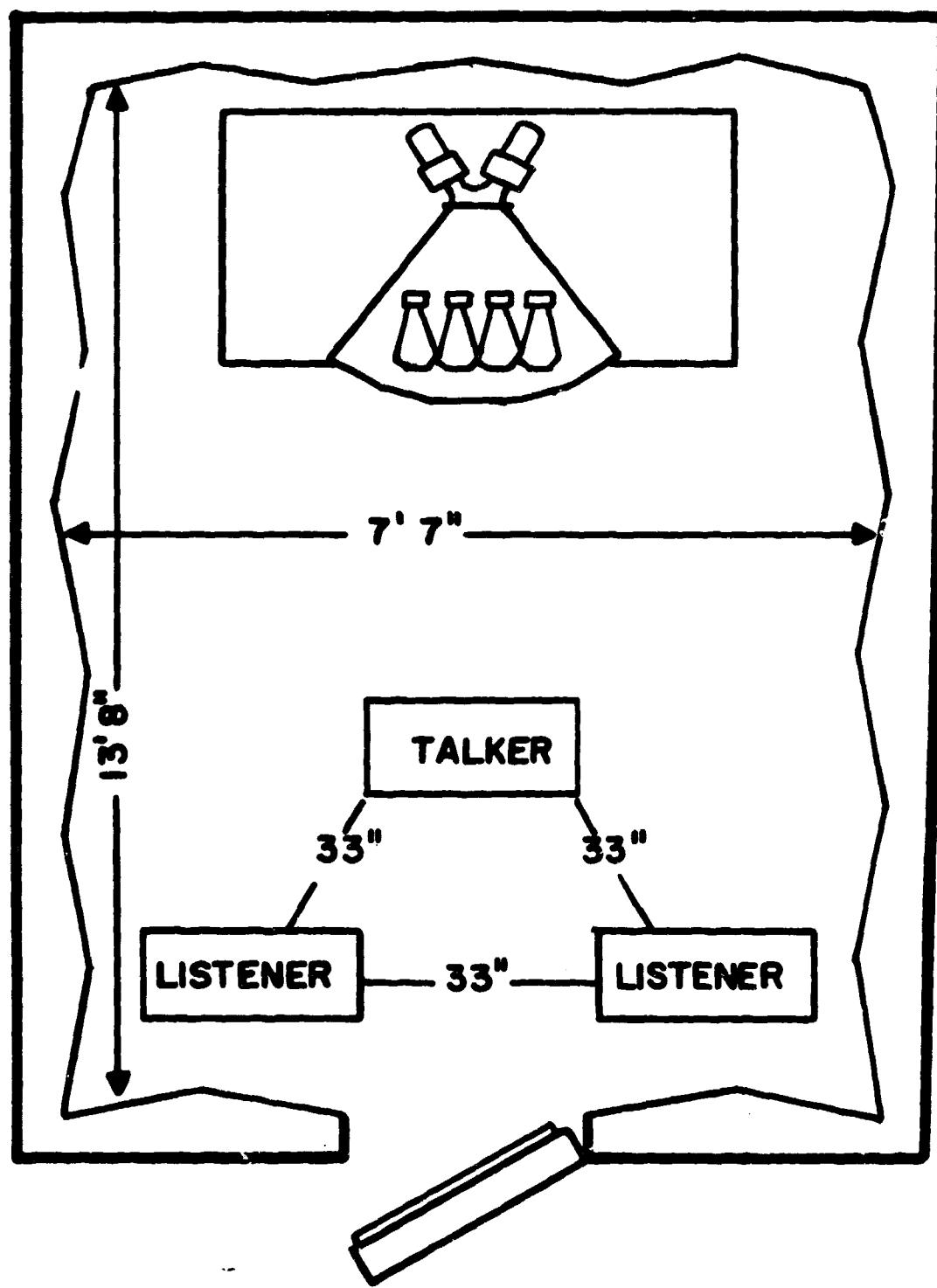


Figure 1

A Schematic Diagram of Test Room and Talker/Listener Positions for the Laboratory Tests

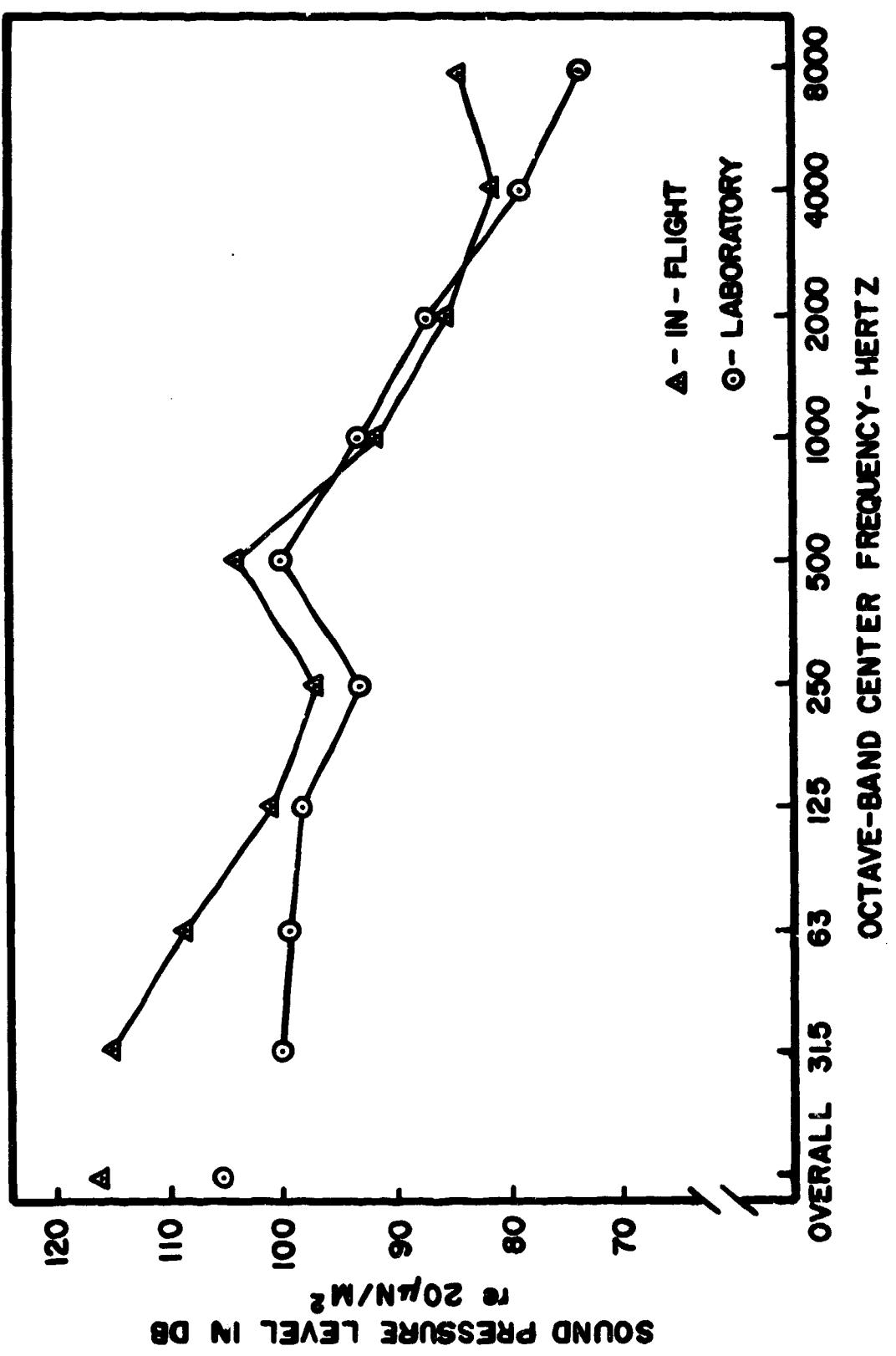


Figure 2

Frequency Spectra of the Noise in the Laboratory and In-flight Test Situations

approximated the levels measured for those bands in flight. Figure 2 shows the frequency spectrum of the noise in each of the two test situations.

#### RESULTS AND DISCUSSION

The results of the laboratory tests are presented in Table I. Shown in the table are percent correct listener scores averaged over two talkers for the closed and open ear test conditions. Since Subject 9 served as a talker and listener in all three talker/listener groups, his scores were averaged over eight talkers. Except for two listeners, one of whose scores for the two test conditions were the same, higher intelligibility scores were obtained for the closed ear test condition. A two-tailed t-test was applied to test the significance of the mean difference between the two sets of scores. The 6 percent mean difference was not statistically significant at the .05 level of confidence.

The results of the in-flight tests are presented in Table II. The mean intelligibility scores for the two test conditions, and the mean difference between test conditions, were essentially the same as those obtained for the laboratory tests. With the exception of two listeners whose scores for the two test conditions were identical, higher intelligibility scores were obtained for the closed ear test condition. The 7 percent mean difference between the closed and open ear test conditions for the in-flight tests was statistically significant (<0.025 level of confidence).

These data confirm the previously mentioned laboratory findings by Kryter. More specifically, the data demonstrate that the wearing of earplugs in rotary-wing aircraft will not interfere with the reception of speech; on the contrary, their use should improve speech reception. That the use of earplugs can aid passengers traveling in rotary-wing aircraft in terms of both speech reception and ear protection would indicate that they should be made available to all individuals traveling in such aircraft.

**Table I**  
**Percent Correct Listener Scores for the Closed Ear  
and Open Ear Laboratory Test Conditions**

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<u>Subject</u>	<u>Closed Ear</u>	<u>Open Ear</u>	<u>Difference</u>
1	52	57	-5
2	51	39	12
3	72	45	27
4	48	46	2
5	57	57	0
6	69	56	13
7	49	48	1
8	45	44	1
9	56	49	7
Mean	55	49	6

---

**Table II**  
**Percent Correct Listener Scores for the Closed Ear  
and Open Ear In-flight Test Conditions**

<u>Subject</u>	<u>Closed Ear</u>	<u>Open Ear</u>	<u>Difference</u>
1	58	58	0
2	53	47	6
3	55	51	4
4	63	45	18
5	60	50	10
6	61	60	1
7	39	39	0
8	58	41	17
9	62	52	10
<b>Mean</b>	<b>56</b>	<b>49</b>	<b>7</b>

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## APPENDIX A

### Brief Description of the Modified Rhyme Test

The Modified Rhyme Test is a multiple-choice intelligibility test that was designed for routine use by operational personnel for determining the performance level of speech communication systems. The materials consist of six equivalent word lists of 50 words each. Each ensemble is characterized by one vowel that is the nucleus of every word in it; all of the words in a given ensemble are initiated (or terminated) by the same consonantal phoneme or phoneme cluster, and are terminated (or initiated) by six different phonemic elements. The listener has available a closed set of six alternatives from which he is required to select his identification of the message. Samples of two such sets of alternatives are shown below:

led	shed	red
bed	fed	wed

(initial consonant variable)

bat	bad	back
bass	ban	bath

(final consonant variable)

Although the test lists are not balanced to approximate the long-time phonemic distribution of American English conversation, the materials retain a high degree of phonemic similarity from test form to test form and, in addition, contain representatives from the major classes of speech sounds.

Unclassified

Security Classification

**DOCUMENT CONTROL DATA - R & D**

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) <b>Naval Aerospace Medical Research Laboratory Pensacola, Florida 32512</b>		2a. REPORT SECURITY CLASSIFICATION <b>Unclassified</b>
		2b. GROUP <b>N/A</b>
3. REPORT TITLE <b>THE EFFECT OF EARPLUGS ON PASSENGER SPEECH RECEPTION IN ROTARY-WING AIRCRAFT</b>		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) <b>N/A</b>		
5. AUTHOR(S) (First name, middle initial, last name) <b>Carl E. Williams, John R. Forstall, and Ward C. Parsons</b>		
6. REPORT DATE <b>27 October 1970</b>	7a. TOTAL NO. OF PAGES <b>10</b>	7b. NO. OF REFS <b>5</b>
8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) <b>NAMRL-1121</b>	
b. PROJECT NO. <b>BuMed MF 12.524.005-7011BX5X</b>	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) <b>2</b>	
c.		
d.		
10. DISTRIBUTION STATEMENT This document has been approved for public release and sale; its distribution is unlimited.		
11. SUPPLEMENTARY NOTES <b>Study conducted under AIRTASK No. A3405314/561B/1F12524402 for Naval Air Systems Command</b>	12. SPONSORING MILITARY ACTIVITY	
13. ABSTRACT <p>Direct person-to-person speech communication is sometimes required in rotary-wing aircraft where high levels of noise make the use of hearing protective devices desirable. The question arises as to what effect earplugs would have on the intelligibility of speech in rotary-wing aircraft.</p> <p>Intelligibility test data obtained in flight as well as in a simulated flight situation indicate that the use of earplugs in rotary-wing aircraft will improve the reception of direct person-to-person speech communication. Moreover, their use will afford protection against the deafening, fatigue, and annoyance effects of the hazardous noise present in rotary-wing aircraft.</p>		

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S/N 0101-807-6801

Unclassified

Security Classification

Unclassified  
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Speech Intelligibility						
Hearing Protection						
Aircraft Noise						
Earplugs						

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Security Classification